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# PATENT SPECIFICATION

933,758

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## COMPLETE SPECIFICATION

### DRAWINGS ATTACHED

### Glandless Solenoid Valve

We, ELEMAG-ANSTALT, of Vaduz, Liechtenstein, a Company duly organised under the laws of Liechtenstein, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

The invention relates to a glandless solenoid valve in which the valve member is connected to an armature operated by an energising winding and is thrust towards its seat by an adjustable spring disposed in a magnetic core.

A disadvantage of known solenoid valves of this kind is that their accuracy is unsatisfactory and, more particularly, they cannot be adjusted to the working pressure of the fluid, nor to the maximum required throughflow, when in operation. According to the invention, to obviate this disadvantage the width of an air gap which exists, with the valve in the closed state, between the magnetic core and the magnet armature, the same being sealed off from the interior of the valve casing by resilient bellows, is adjustable.

An embodiment of the subject-matter of the invention is illustrated in longitudinal section in the single Figure forming the drawing.

The valve illustrated comprises a valve casing 1 having entry port 2, an exit port 3 co-axial thereof, and an intermediate wall 4. The same has a passage 5, the top edge of which forms a seat 6 for a spherical valve member 7. The entry port 2 has an internal screwthread 8 and the exit port 3 has an internal screwthread 9, the screwthreads 8, 9 being for connection purposes. The casing 1 comprises a third port 10 which perpendicular to ports 2, 3 and is in alignment with the passage 5. The port 10 has a

connection flange 11; secured thereto, with the interposition of a gasket 12 and of a flanged ring 14, the gasket 12 being received in an annular groove 13 in flange 11, is a winding casing 15, the securing being by means of screws 16. A cylindrical armature 18 can move axially in a central passage 17 in the flanged ring 14; the bottom end of the armature 18 is screwed to the top end of a stem 20 which terminates at its bottom end in the spherical valve member 7. A shouldered annular flange 21 is either disposed on or formed in one piece with the stem 20. The two ends of metallic spring bellows 22 are soldered to flanges 14 and 21; bellows 22 engage around the bottom end of armature 18 and are received in passage 23 in port 10. Armature 18, port 10, bellows 22, stem 20, rings 14, 21 and passage 5 are therefore co-axial of one another.

The winding casing 15 contains a solenoid winding 24 which is relatively small as compared with winding of known solenoid valves of similar capacity, and the magnetic circuit of the winding is formed mainly by the iron casing 15. The same comprises a base 25, a cover 26 and an outer generated part 27 which is connected to base 25 by screw 28 and to cover 26 by screw 29. The winding 25 is wound on an insulating tubular former 30 having two insulating flanges 31, 32; the bottom flange 31 bears against the base 25 with the interposition of a resilient insert 33, while the top flange 32 engages directly with cover 26. The ends of the wire which forms the winding are connected to two terminals 34. A tube 35 made of brass or some other non-ferromagnetic substance extends to about half way up the height of the former 30 from the bottom thereof; the tube 35 has its bottom end secured to the casing base

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Price 25p

57 500 1 112 78

25 and guides the armature 18. Extending into the tubular former 30 from the top is a magnetic core 36 provided outside the former 30 with an external screwthread 37 which is screwed into a matching screwthread in a central passage 38 in cover 26. A cap 39 is screwed onto the external screwthread 37; when the cap 39 is removed, access can be had with a screwdriver to a transverse slot 40 in the top end of core 36. However, before core 36 can be adjusted with the screwdriver, a locknut 41 also disposed on external screwthread 37 must first be released; when the cap 39 is in position, locknut 41 is received in an annular groove 42 therein.

Core 36 is pierced right throughout its length and the passage 43 therein receives a non-ferromagnetic axially moveable thrust pin 44 having at its bottom a head 45, a compression spring 46 received in passage 43 bears at the top against a screwthread pin 47 which is screwed into an internal screwthread 48 in the passage 43 which is widened in this zone, the spring 46 bearing at the bottom against the head 45 and therefore maintaining the same in engagement with the top end of the armature 18. Pin 47 is formed with an axial passage 49, adapted to guide the pin 44, and with a transverse slot 50, engageable by a screwdriver, the blade of which must be formed with a nick for the top end of pin 44.

The solenoid valve described operates as follows:

When the valve is in the closed position illustrated in the drawing, the force of the spring 46 must be large enough so to act on armature 18 via head 45 as to overcome the positive pressure of the liquid which is operative upwards on armature 18 through valve member 7. The force of spring 46 is controlled by adjusting the position of the hollow screwthread pin 47 to the required value.

If when the valve is in the closed state the positive pressure of the liquid on the entry side thereof is relatively large as compared with the positive pressure on the exit side thereof, for instance about 10 atmospheres absolute, a relatively large force, for instance, of more than 20 kg., must be exercised from spring 46 to maintain valve member 7 on its seat 6, on the assumption that the cross-sectional surfaces of passage 5 are about 2 cm<sup>2</sup>. When the valve member 7 lifts off its seat 6, the upward pressure operative on the valve member 7 decreases very considerably, the pressure drop of 10 atmospheres absolute being distributed throughout the whole piping, most of the pressure drop occurring across the passage 5 in the intermediate wall 4. As the spring 46 is adjusted to exercise a comparatively large force, the

magnetic force must be large to overcome the force of said spring also when the fluid flows in the piping. In order that the relatively small winding 24 may produce such a large magnetic force, core 36 is screwed relatively far into the tapped passage 38 in cover 26 so that the width  $s$  of the air gap between armature 18 and core 36 is small. The pressure at the exit end of the passage 5 acts not only on the valve member 7 but also on the ring 21 forming the base of the bellows 22. The downwardly operating force of the spring 46 and of the air included in the gap  $s$ , such force increasing as the said air gap width  $s$  decreases, the upwardly operative magnetic force, which, even more so than the last-mentioned force, increases with decreasing air gap width  $s$  for a given energising current, and the upwardly operative hydraulic force, which decreases slightly with decreasing air gap width  $s$ , lead to an equilibrium condition such that the energising current must be increased to open the valve fully—i.e. to move valve member 7 from its closed position into its position of maximum opening, such position being limited by armature 18 abutting core 36.

If the positive pressure operative when valve member 7 is in the closed position is fairly low, for instance 1 atmosphere absolute, the pressure of the spring 46 need be adjusted only to slightly over 2 kg, and core 36 must be so adjusted that the air gap width  $s$  associated with the closed position is correspondingly greater than in the case first considered so that the valve starts to open at substantially the same energising current as in the previous case. In both cases, if the position of the core 36 is correctly adjusted relatively to the cover 26 and if the position of the hollow pin 47 is correctly adjusted relatively to the core 36, a very even control characteristic will be provided so that the quantity of liquid flowing through can be adjusted definitely and very accurately by adjustment of the energising current and the valve member 7 remains in the position to which it is adjusted without flutter.

The core 36 and the pin 47—i.e., the force of the spring 46—can be adjusted at any time during operation, since the spring bellows 22 prevent the liquid from reaching the parts to be adjusted and therefore prevent liquid from entering the adjusting screwthreads. No liquid can therefore leak through such screwthreads during adjustment, nor can incrustations be formed in such screwthreads by deposition of foreign bodies contained in solution in the liquid. Since the closing pressure and the maximum valve opening can be adjusted very delicately and readily during operation, the valve according to the invention

has a great advantage over similar glandless valves in which the armature is disposed, for instance, in a hollow member made partly of magnetic material and partly of amagnetic material and surrounded by the energising winding, with the chance of the liquid penetrating into the interior of the hollow member. The improved accuracy of adjustment means that the energising winding can be much smaller than in known solenoid valves.

Conveniently, the diameter of the base of the bellows 22—i.e. the relatively large external diameter of flange 21—is greater than the diameter of the valve passage 5 and is, for instance, more than twice as great as the last-mentioned diameter, as in the drawing, and is preferably at least 1.5 times as great. Also, the spring bellows 22 when unloaded should engage internally at least substantially with the bottom part of the armature 18. When the bellows 22 are loaded—i.e., when there is a positive pressure below the base 21 of the bellows 22—the interior thereof engages completely with the armature, the same acting as a support for the bellows 22.

#### WHAT WE CLAIM IS:—

1. Glandless solenoid valve in which the valve member is connected to an armature operated by an energising winding and is thrust towards its seat by an adjustable spring disposed in a magnetic core, characterised in that the width axially of the armature of an air gap which exists, with the valve in the closed state, between the said magnetic core and the magnet armature is adjustable, the said armature being sealed off from the interior of the valve casing by resilient bellows.

2. Solenoid valve according to claim 1 characterised in that the magnetic core is adapted to be screwed into the cover of a ferromagnetic casing containing the ener-

gising winding, and the force of the said adjustable spring can be adjusted by screwing a screwthread pin into the magnetic core.

3. Solenoid valve as set forth in claim 2 characterised in that a cap formed with an annular groove adapted to receive a lock-nut is screwed on to the top end of the magnetic core, such end having an external screwthread for such a purpose.

4. Solenoid valve as set forth in claim 1 characterised in that the said width of the air gap is equal to the maximum opening movement of the valve member.

5. Solenoid valve as set forth in the preceding claim characterised in that the position of the valve member between the closed position and the maximum open position can be definitely adjusted by adjustment of the energising current.

6. Solenoid valve as set forth in claim 1 characterised in that the said magnetic core and the armature extend from opposite ends into a tubular former on which the energising winding is wound.

7. Solenoid valve as set forth in claim 1 characterised in that the diameter of the base of the resilient bellows is at least 1.5 times as great as the diameter of the valve passage which is covered by the valve member in the closed state.

8. Solenoid valve as set forth in claim 1 characterised in that the resilient bellows when unloaded engages internally at least substantially with the bottom part of the armature.

9. A glandless solenoid valve constructed substantially as herein described and as illustrated in the accompanying drawings.

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COMPLETE SPECIFICATION

1 SHEET

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